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ABSTRACT

A framework is proposed in which on-line activities occurring during comprehension are explicitly tied to the memory representation of a story. The framework, referred to as the "landscape" framework, is used to implement a process model that assumes that readers attempt to explain story events in terms of their causal antecedents. An attempt is then made to validate the model by comparing its predictions for on-line and off-line behavior to the behavior of human subjects. To measure the inferences occurring at each point in the text, 1,835 subjects were asked to think aloud as they read the story, and on-line predictions were compared to the ideas mentioned by the subjects. To obtain a measure of the actual representational strength of story ideas in memory, 79 subjects were asked to recall as much as possible of the story after a short delay. The correlation between the on-line predictions for the activation of story ideas and their frequency of mention during "think-aloud" and the correlation between the strength predictions for story ideas and their frequency of mention during recall were both significant, supporting the model as a psychologically valid account of processing principles. The landscape framework is a useful tool for investigating comprehension. (Contains 4 figures and 1 table.) (SLD)

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EXPLANATION-BASED PROCESSING IN NARRATIVE COMPREHENSION

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One of the most important goals of education is that of transferring information to students. Unfortunately, instructors and/or instructional materials are not always successful at conveying information, on the one hand, and on the other hand, students do not always successfully receive information even when it is well presented.

How might we remedy this situation to make instruction more effective and learning more likely? One strategy is to look to instructional conventions which do successfully convey information and which are, in general, successfully received by students. Narrative discourse constitutes one such convention. Throughout time, narrative has remained a fundamental medium for the transfer of knowledge. Moreover, narrative discourse has been shown to be more effective in this regard than expository and descriptive discourse. By understanding the structure of narrative text and how people process it, we may gain important insights as to how to improve learning in educational settings.

Given the above discussion what do we know about the structure and processing of narrative text? How do people learn from stories? It is widely assumed that in order to understand a story, and thus learn from it, a reader must create a mental

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representation that includes both the individual story ideas and the relations between them. (See Figure 1). Although many relation types are involved in structuring and organizing story representations, causal relations have been found to be particularly important in this regard. The greater the number of causal relations that exist between parts of a story, the more coherent, and understandable it is perceived to be. Furthermore, the more time readers spend explaining events in terms of their causal antecedents, the better they remember those events and the story in general.

Although many studies have demonstrated that causal relations are, indeed, inferred during comprehension, and that they do form the basis for the representation of story information in memory, very little research has been directed toward understanding exactly how transient activities occurring during comprehension result in a relatively stable structure in memory that can be accessed and used at a later point in time. (See Figure 2). As a result, it has often been difficult to determine the implications of theories and experimental findings which address one or the other end of the spectrum for comprehension as a whole. Nevertheless, understanding how this transition takes place is important if we want to understand story comprehension in its entirety and if we wish to use that understanding to improve learning. Addressing the specific issue of how on-line activities result in off-line representation is the goal of our present research.

In this research we a) propose a framework in which on-line activities (e.g., activities occurring during comprehension) are explicitly tied to the memory representation of a story b) use the framework to implement a process model which assumes that readers attempt to explain story events in terms of their causal antecedents and c) validate the model by comparing its predictions for on-line and off-line behavior to the behavior of human subjects.

The Landscape Framework

Within our proposed framework, processing is conceptualized as continuous fluctuations in the activation levels (or relative accessibility in working memory) of story concepts over input cycles where input cycles correspond, in the present case, to sentences. Relational connections between concepts are formed as a function of the degree to which they are co-active. Activation itself is a function of story input; temporal order; associative, referential, and causal relations between story ideas; and/or prior co-occurrence in the story. (See Figure 3).

More concretely, within this framework, comprehension is thought of as a "landscape" of concept activations that fluctuate over the course of the story. The trace of that landscape pattern forms the basis of the story representation in memory. Figure 4 provides the "landscape" pattern that is formed as a result of processing The Knight Story.

Implementation of an Explanation-based Process Model

The Landscape framework has been implemented within a recurrent connectionist architecture. One feature of the implementation is that the activation levels of concepts at any point in the story can be hand-set to accord with various theoretical notions of which relations are identified during comprehension. In order to simulate explanation-based processing for a simple, hierarchical story based on Mercer Mayer's, A Boy, a Dog and a Frog we simply activated the causal antecedents of focal events.

The result of simulating comprehension in this manner is two sets of data. The first set of data provides quantitative predictions for the activation levels of each concept at each point in the story. These predictions should correspond to the inferences that human subjects generate over the course of comprehension. The second data set provides theoretical predictions for the strength of the connections between each concept and all the others. Importantly, these strength values are a direct function of activation patterns during comprehension. Summing these connections strengths over concepts provides an index of how strongly encoded and central to the story a given idea is. These "strength" values should correspond to the memorability of the story ideas.

Validation of the Model

In order to validate the model, a) the on-line and off-line predictions were compared to the actual comprehension behavior of human subjects and b) the fit of the explanation-based model to the human data was compared to that of alternative models.

To obtain a measure of the inferences occurring at each point in the text, our subjects participated in a "think-aloud" task in which they were asked to report each thought that came to mind as they read the story. On-line predictions regarding the activation of story ideas at each point in the text were compared to how frequently the ideas were mentioned by our subjects.

To obtain a measure of the actual representational strength of story ideas in memory, our subjects were also asked to recall as much as possible of the story after a short delay. The off-line "strength" predictions were compared to the frequency with which story ideas were recalled across subjects.

Correlational analyses indicated that the predictions of the explanation-based model of comprehension accounted for both the on-line and off-line comprehension behavior of human subjects. (See Table 1). The correlation between the on-line predictions for the activation of story ideas and their frequency of mention during the "think-aloud" task and the correlation between the strength predictions for story ideas and their frequency of mention during recall were both significant. These findings establish the model as a psychologically valid account of the processing principles that drive

comprehension activity and result in a memory representation of a narrative text.

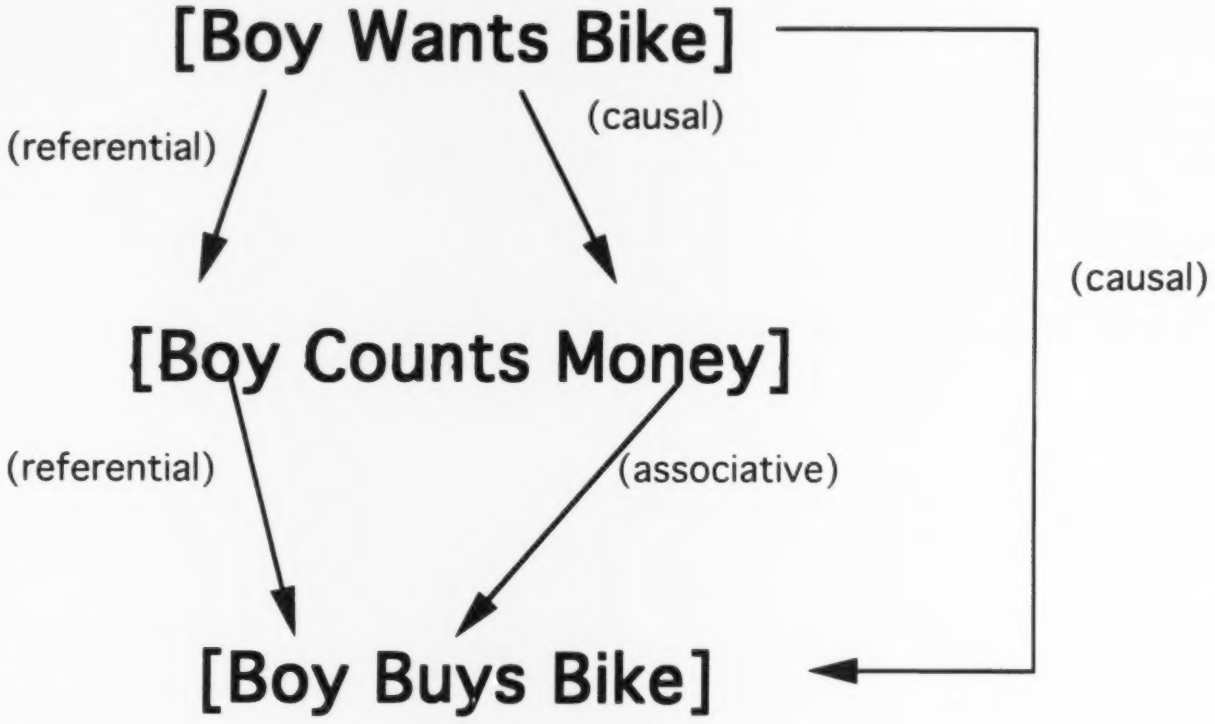
How does the explanation-based model compare to alternative models with different processing assumptions? For example, how does the model compare to an alternative model that assumes that readers do not engage in explanation-based processing at all; that is that causal connections are never formed and that the only structure that results from processing is based on temporal ordering? Alternatively, how does the explanation-based model compare to a model that assumes that causal connections are formed only when the reader can readily do so; as, for example, when causal antecedents are adjacent to focal ideas in the text?

In order to address these questions two additional simulations based on the assumptions discussed above were run within the Landscape framework and respectively compared to the think-aloud and recall data. As shown in Table 1, correlational analyses indicated that the simulation based purely on temporal ordering (i.e., the order only model) provided a poor fit to both the think-aloud and recall data. Further analyses indicated that the fit of the simulation based on formation of local causal connections (i.e., the localist model) was mixed. Whereas the magnitude of the correlation between the on-line predictions of the model and the think-aloud data approached that for the explanation-based model, the off-line predictions of the localist model were not correlated with frequency of mention in the recall data. These results lend further support to the explanation-

based model by demonstrating that it provides a better fit to human data than alternative models of comprehension.

Conclusions

Several conclusions can be drawn from our research. First, readers actively engage in "effort after meaning" by attempting to establish a coherent explanation for story ideas. Following from the first conclusion, a second conclusion is that instructors and instructional materials should endeavor to support the explanation process and to explicitly teach students how to engage in explanation-based processing. A third and final conclusion of this research is that the Landscape Framework provides a useful tool for investigating comprehension in its entirety and for comparing the implications of different theories of comprehension.


[Boy Wants Bike]
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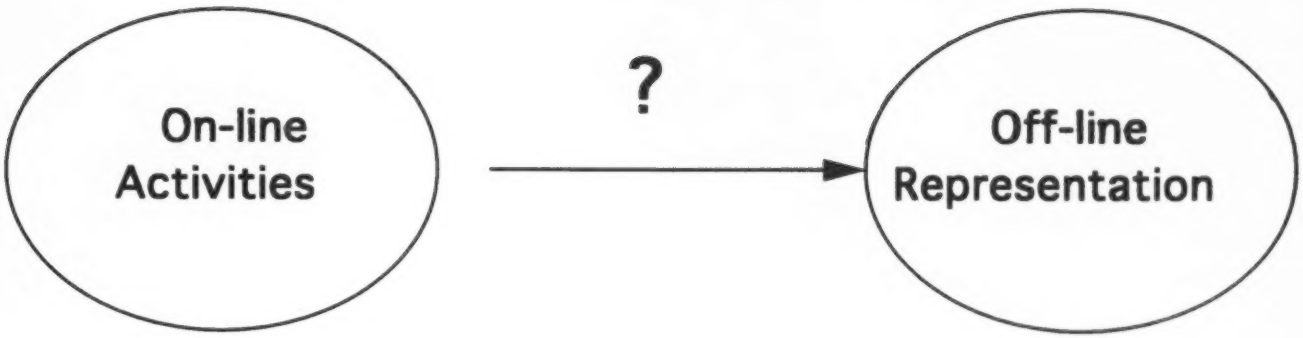
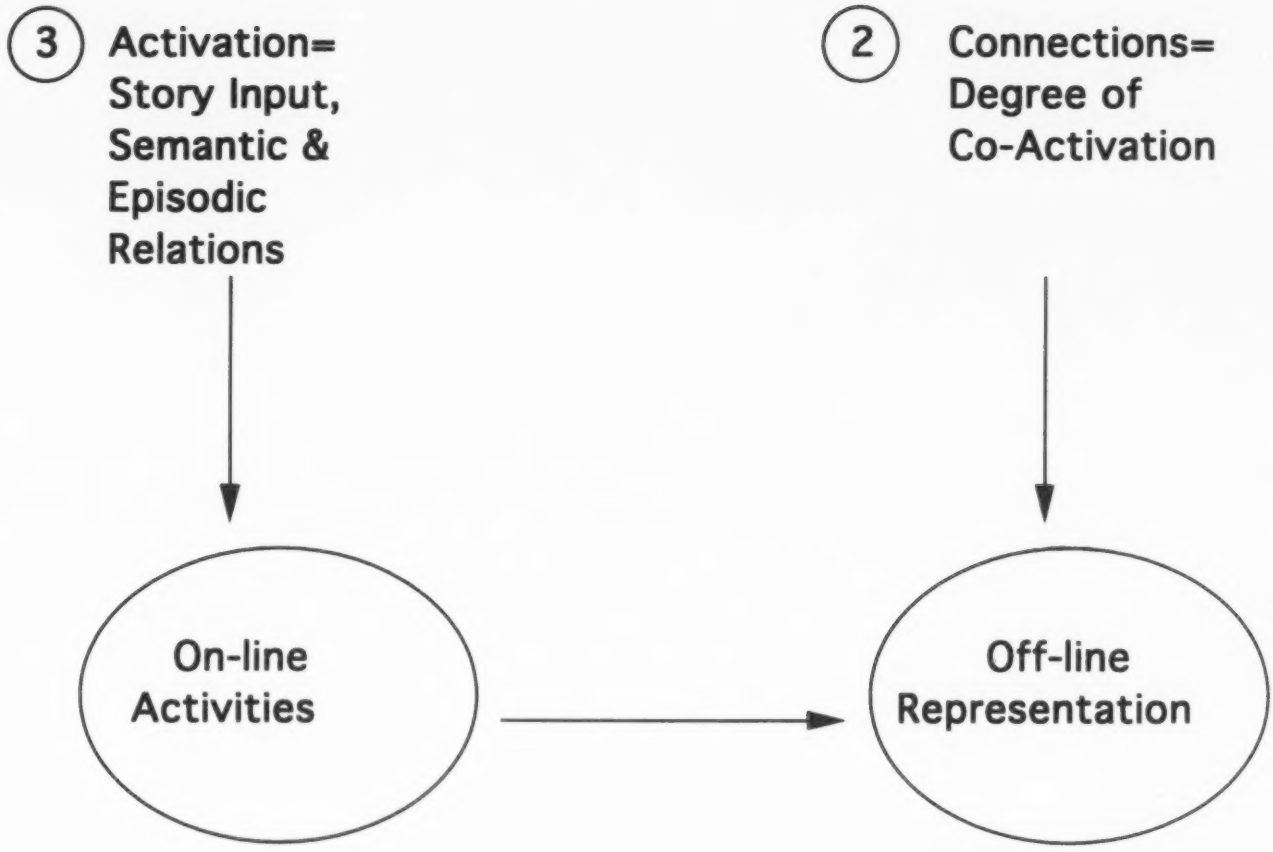
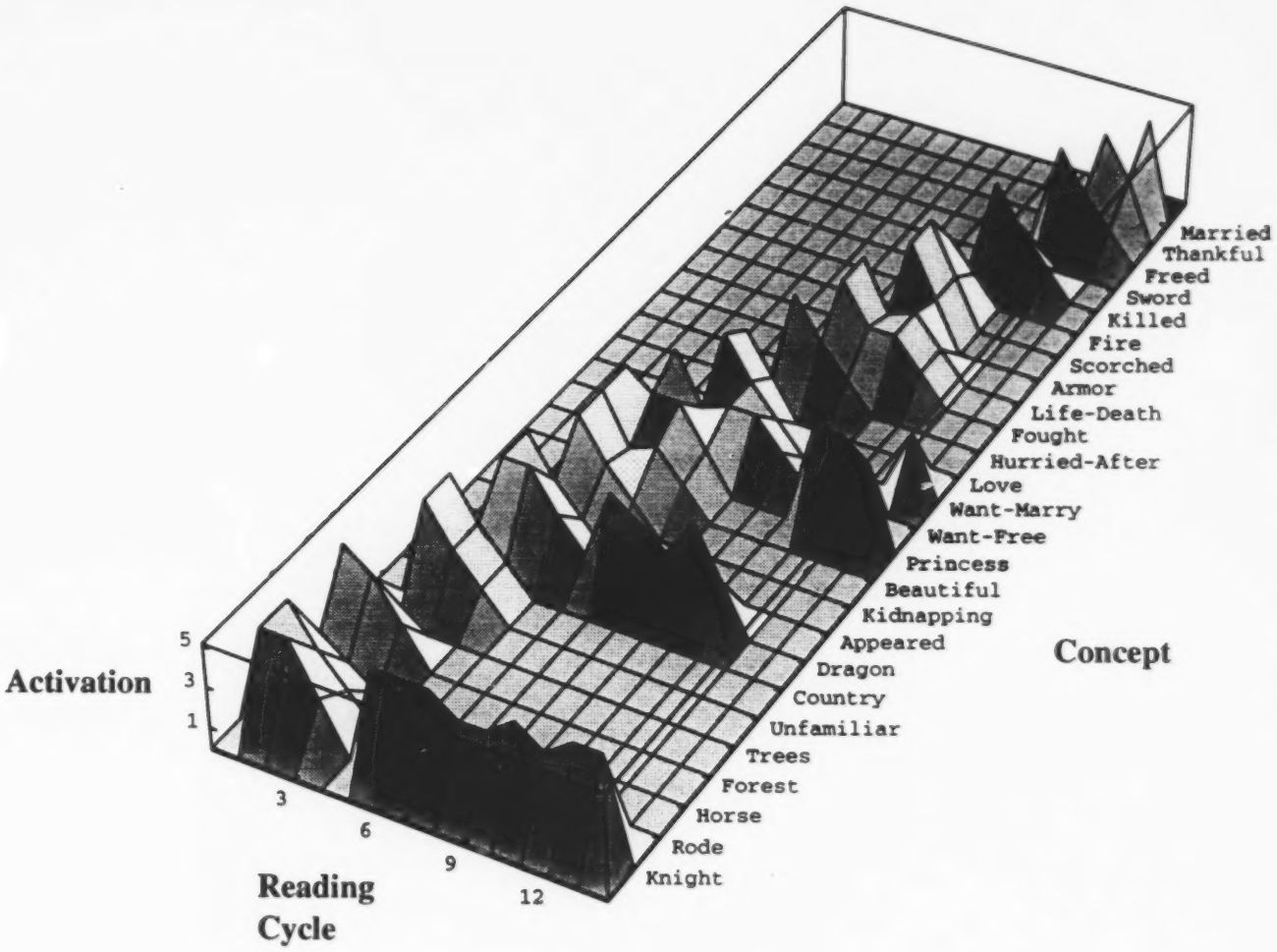
[Boy Counts Money]
(referential)
(associative)
[Boy Buys Bike]


On-line
Activities
?
Off-line
Representation


3 Activation= Story Input, Semantic & Episodic Relations
2 Connections= Degree of Co-Activation
On-line Activities
Off-line Representation

1 Processing= Fluctuating Activation over Input Cycles


Activation
5
3
1
3
6
9
12
Reading Cycle
Knight
Rode
Horse
Forest
Trees
Unfamiliar
Country
Dragon
Appeared
Kidnapping
Beautiful
Princess
Want-Free
Want-Marry
Love
Hurried-After
Fought
Life-Death
Armor
Scorched
Fire
Killed
Sword
Freed
Thankful
Married
Concept

Fit of Models to Behavioral Data

Model	Think-Aloud	Recall
Explanation-based	r = .38*	r = .34*
Order Only	r = .15*	r = .06
Localist	r = .34*	r = .20
	n = 1835	n = 79

*p<.01.